TIDAL RAINFALL OF PHILADELPHIA.

Read July 17th and October 2d, 1868.

By Pliny Earle Chase.

I have already given a portion of the evidence which indicates a tendency to increase of rain at quadrature and decrease at syzygy. In order to ascertain how far that evidence may be confirmed or modified by other considerations, it seemed desirable to undertake a more general examination and comparison of observations. The data for such an investigation were derived from the following sources:

1. The meteorological register of the Pennsylvania Hospital at Philadelphia, covering a period of forty-three and a half years, from January 1, 1825 to July 1, 1868. This register was in charge of Newberry Smith from 1825 to 1828, of Franklin Smith from 1828 to 1831, and of Dr. John Conrad from April 1, 1831, to the present time.

2. The published record, in three octavo volumes, of five years' observations at Girard College, Philadelphia, from June 1, 1840, to July 1, 1845.

3. The register of Prof. James A. Kirkpatrick, of the Central High School, Philadelphia, from July 1, 1851, to July 1, 1868.

4. Mr. Glaisher's summary of six years' hourly observations of the rainfall at Greenwich, England, in the Proceedings of the [British] Meteorological Society, Vol. IV. No. 33.

5. Mr. Dines's discussion, in the same Proceedings (Vol. IV. No. 36), of forty years rainfall at Cobham Lodge, Surrey, England.

6. Blodgett's tables of monthly rainfall at thirty-seven stations in Western and Southern Europe, and nineteen stations in Central Europe and Asia.*

7. Loomis's table of monthly rainfall at forty-five North American stations.†

In the preliminary comparison the Hospital observations were arranged in weekly groups for each quadrature and syzygy, and for each apsis, the critical day in each group being the mid day of the seven. They were also arranged according to the moon's latitude and declination. From the results of this comparison, which are given in Tables I—III., as well as from the portions

* Climatology of the United States, pp. 64-5.

† Treatise on Meteorology, pp. 278-9.

TABLE I.

Amount of Rain at Philadelphia, in different portions of the Lunar Month.

YEARS.	Week of New Moon.	Week of First Quarter.	Week of Full Moon.	Week of Last Quarter.	Two Weeks of Syzygy.	Two Weeks of Quadrature.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1825–34	92.47	87.52	88.72	100.57	181.19	188.09
1835–44	93.64	106.83	100.72	113.49	194.36	220.32
1845–54	91.05	94.25	108.00	96.98	199.05	191.23
1855–64	113.45	112.71	86.02	114 24	199.47	226.95
1825–68	436.31	439.86	447.53	460.43	883.84	900.29

TABLE II.

Amount of Rain at Philadelphia, at various Critical Lunar Periods.

YEARS.	Week of Perigee.	Week of Apogee.	North Declination.	South Declination.	North Latitude.	South Latitude.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1825–34	94.20	105.67	180.73	170.52	161.66	202.87
1835–44	90.42	111.98	211.91	206.60	212.06	203.59
1845–54	106.40	106.23	196.20	198.56	188.35	199.15
1855–64	118.31	109.21	202.77	218.73	201.37	220.27
1825–68	459.22	479.73	868.69	893.14	857.61	902.59

TABLE III.

Number of Storms at Philadelphia, at different Lunar Periods.

YEARS.	Week of New Moon.	Week of First Quarter.	Week of Full Moon.	Week of Last Quarter.	Week of Perigee.	Week of Apogee.	North Declination.	South Declination.	North Latitude.	South Latitude.
1825–34	216	196	212	229	238	237	418	411	406	439
1835–44	237	272	256	265	239	272	485	531	525	502
1845–54	294	268	278	276	298	281	543	558	559	552
1855–64	289	311	272	300	310	328	568	610	564	602
1825–68	1141	1152	1131	1168	1206	1239	2216	2348	2280	2298

of the day in which rains were most prevalent (Table IV.), it appeared probable that *an increase of tidal attraction is accompanied by a tendency to fair weather, and a diminution by a tendency to increased rainfall.* The tendencies are, however, so

TABLE IV.

Number of Rains in different Quarters of the Day, at Philadelphia.

YEAR.	RAINS ON SOLAR QUARTER-DAYS.											
	Beginning.				Continuing.				Ending.			
	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21
1851(½y)..	15	32	10	10	26	49	29	23	11	31	16	12
1852.....	38	45	17	21	54	64	34	43	35	35	14	25
1853.....	31	52	23	20	54	76	35	40	33	50	25	19
1854.....	28	42	15	13	67	72	46	46	39	40	11	20
1855.....	34	43	14	29	70	75	54	57	40	37	20	26
1856.....	35	38	6	23	56	68	37	41	30	39	8	14
1857.....	33	48	22	40	64	84	52	68	25	46	24	55
1858.....	39	47	33	35	66	81	60	71	39	46	57	43
1859.....	39	62	37	25	78	103	73	56	44	49	50	19
1860.....	52	75	37	22	79	106	83	51	42	58	56	24
1861.....	39	57	36	34	65	78	72	54	41	46	49	24
1862.....	35	55	34	35	80	89	85	69	51	44	47	21
1863.....	39	51	35	31	82	96	82	62	41	52	47	23
1864.....	38	47	41	35	75	83	70	61	42	49	46	26
1865.....	36	46	34	21	72	86	67	54	34	48	42	20
1866.....	34	49	35	17	65	85	82	48	31	39	48	10
1867.....	44	55	45	37	90	104	90	76	46	59	54	36
1868(½y)..	19	21	19	13	47	53	53	34	17	21	30	10
17 years...	628	865	493	466	1190	1452	1104	954	641	789	644	427

YEAR.	RAINS ON LUNAR QUARTER-DAYS.											
	Beginning.				Continuing.				Ending.			
	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21	h. 21 to 3	h. 3 to 9	h. 9 to 15	h. 15 to 21
1851(½y)..	8	20	15	17	24	31	30	32	10	18	14	16
1852.....	27	32	34	27	45	50	51	49	25	28	23	30
1853.....	38	28	19	39	60	62	43	64	22	37	18	38
1854.....	26	24	19	34	62	64	49	60	23	36	22	27
1855.....	28	30	34	27	72	65	65	70	30	33	25	25
1856.....	27	29	23	24	56	57	53	53	23	20	19	26
1857.....	39	28	24	30	82	91	73	68	27	33	24	28
1858.....	40	35	22	32	85	82	69	74	42	34	21	23
1859.....	29	49	25	30	79	99	79	76	25	38	26	24
1860.....	37	43	21	38	80	91	65	73	28	41	28	30
1861.....	34	43	23	26	76	93	62	63	20	48	22	28
1862.....	35	29	24	26	85	87	83	74	28	27	26	21
1863.....	22	44	33	30	66	88	84	81	28	30	28	33
1864.....	40	33	25	33	73	80	75	75	34	31	27	37
1865.....	28	36	23	25	67	76	70	77	23	29	20	36
1866.....	34	29	22	25	74	77	62	62	23	35	27	22
1867.....	44	33	31	38	89	85	90	78	37	32	36	33
1868(½y)..	20	11	18	13	47	46	44	39	14	20	16	11
17 years...	556	576	435	514	1222	1324	1147	1168	462	570	422	493

slight as to be easily overcome, and sometimes for five or more consecutive years, and for periods of ten years or more, this law of precipitation appears to be entirely reversed. Some indications of a probable cause for this vacillation appeared to be furnished by the barometric octantal tides which I had previously pointed out (*ante* IX., 398; Proc. Roy. Soc. June 16, 1864), and these indications were strengthened by Mr. Hennessey's report of the observations at Mussoorie, which showed not only a greater rainfall at each quadrature than at either syzygy, but also a general octantal maximum.

TABLE V.

Philadelphia Rainfall and Barometric Means on different days of the Lunar Month.

Age of Moon.	1825 to 1834.	1835 to 1844.	1845 to 1854.	1855 to 1864.	1825 to 1868.	Barom. Obs'ed. 1840–5.	Barom. Normals 1840–5.
						Inches.	*Inches.*
0	15.68	13.48	12.25	14.76	63.04	+.013	+.006
1	7.34	15.45	14.71	15.39	59.04	+.019	+.008
2	8.99	11.04	14.06	16.16	54.88	—.001	+.006
3	15.74	14.78	11 72	19.53	73.92	+.003	+.000
4	19.02	15.35	17.36	14.49	74.41	+.000	—.010
5	7.94	8.93	14.59	20.89	55.88	—.030	—.021
6	10.87	19.93	9.96	15.37	62.56	—.035	—.027
7	13.89	12.91	13.80	16.49	64.36	—.034	—.029
8	12.55	13.92	15.38	13.76	60.73	—.011	—.029
9	13.49	17.22	9.48	15.55	61.17	—.042	—.028
10	12.39	19.02	14.39	15.98	66.09	—.045	—.018
11	12.55	15.54	11.45	14.55	56.98	+.020	—.002
12	14.02	17.02	12.27	10.08	59.05	+.022	+.012
13	10.67	22.72	18.84	8.88	64.97	+.015	+.018
14	8.59	14.21	11.23	11.19	57.19	+.034	+.020
15	11.22	11.11	14.29	10.53	63.44	+.047	+.019
16	11.31	18.38	15.45	14.23	69.73	—.013	+.012
17	14.94	11.96	20.50	15.17	72.51	+.014	+.004
18	16.59	16 24	21.94	20.62	81.00	—.002	—.004
19	15.11	20.28	15.17	17.96	72.26	—.012	—.013
20	13.97	10.03	17.09	23.82	68.73	—.032	—.018
21	16.30	18.12	12.92	14.60	68.49	—.031	—.013
22	13.68	17.22	9.83	12.65	57.15	+.019	+.002
23	17.95	18.41	15.57	17.01	74.59	+.004	+.018
24	13.04	23.72	14.53	11.30	68.22	+.050	+.028
25	13.89	8.24	9.17	15.32	49.37	+.029	+.028
26	9.94	7.29	15.2C	23.04	61.92	+.031	+.019
27	18.95	16.39	18.21	17.98	79.11	—.011	+.008
28	13.23	13.78	13.92	15.30	59.67	+.006	+.001
29	6.98	7.11	6.08	3.34	26.09	— 014	+.002

I was therefore led to plot and compare the pluvial and barometric curves, smoothing the irregularities by Airy's method. The normal ordinates (η) were each derived from seven successive observations (y) by the formula $\eta_n =$

$$(y_{n-3}+6y_{n-2}+15y_{n-1}+20y_n+15y_{n+1}+6y_{n+2}+y_{n+3})\div 64$$

This formula appeared to give sufficient weight to any possible shifting of lunar influence, by prevailing winds or other occasional disturbances.

For greater symmetry and simplicity the normal lunar month was assumed to consist of thirty days, the 30th day (moon's age 29) being computed by the formula

$$y_{29}=(y_{28}+4y_{28\frac{1}{2}}+y_0)\div 4$$

The solar hourly barometric curve was constructed from the values given in Guyot's tables (Bache); all the others, from the results of original computation.

TABLE VI.

Number and amount of Heavy Rains (1 *inch or more*) *at Philadelphia, on different days of the Lunar Month.*

Age of Moon.	1825–34.	1835–44.	1845–54.	1855–64.	1825 to 1868.			Amounts Exceeding			
								In. 1.5	*In.* 2	*In.* 2.5	*In.* 3
	No.	No.	No.	No.	No.	Amt.					
0	5	2	3	4	17	20	*In.*	14	9	7	7
1	2	3	3	5	14	24	..	14	4	4	4
2	4	1	3	5	14	21	..	6	3	3	0
3	6	6	2	6	24	34	..	17	5	3	0
4	6	5	9	6	29	48	..	31	16	8	3
5	1	2	4	6	15	21	..	15	7	5	0
6	3	6	2	7	19	28	..	17	4	0	0
7	2	6	6	5	21	33	..	17	12	5	0
8	3	5	6	5	21	29	..	21	5	3	0
9	3	3	0	4	12	29	..	18	11	11	11
10	2	3	6	5	17	23	..	12	5	3	3
11	3	5	3	4	16	24	..	13	8	6	3
12	4	5	2	3	14	23	..	13	7	3	0
13	2	8	5	3	20	27	..	11	8	6	0
14	2	4	3	3	17	25	..	11	6	6	3
15	4	3	5	4	19	33	..	21	18	14	11
16	3	3	5	2	18	32	..	17	9	7	7
17	5	5	8	8	29	39	..	23	4	0	0
18	6	7	6	6	26	52	..	37	29	20	7
19	3	7	3	7	21	31	..	15	8	3	3
20	4	2	3	7	18	35	..	21	16	14	12
21	4	7	5	5	24	38	..	24	14	3	3
22	4	6	5	5	21	33	..	22	15	8	8
23	6	3	6	6	24	42	..	19	14	10	10
24	5	7	6	2	22	36	..	18	13	9	6
25	5	1	4	6	16	19	..	9	2	0	0
26	3	2	4	10	20	38	..	25	20	16	13
27	8	5	7	6	29	42	..	24	12	3	3
28	5	5	5	5	21	38	..	23	11	3	0
29	3	3	1	0	7	11	..	6	4	0	0

The data for determining the Philadelphia hourly rains are not so satisfactory as those for the daily rains. A self-registering gauge was kept at Girard College, but the oft-repeated mar-

ginal notes, "gauge out of order," "rain gauge did not register the hourly fall throughout this month," &c., makes it difficult to decide how much weight should be attached to its records. The Hospital register rarely fixes the limits of a storm with sufficient precision. Prof. Kirkpatrick notes the time of beginning and ending during the day hours, and in some cases at night, and he also gives the amount of fall, after April 1, 1854. Whenever I desired to consider that amount in connection with his earlier observations, it was taken from the Hospital register. Where no more definite marking was available the rain of each storm was distributed equally over the hours of its continuance, the night being considered as beginning at 11 *h.* 30 *m.* and ending at 16 *h.* 30 *m.* From the observations thus arranged the deviations from the mean values were calculated, and those deviations were joined to the Hospital means in order to secure uniformity of standard for comparison.

A combination of the monthly values (Table X.) furnishes the following results:

I.	Philada. 43 years.	Amer.	Marit. Europe.	Central Europe and Asia	Average
Mean of March and September (equinoctial)..	149.4	4.72	2.72	2.35	3.27
" one month from equinoctial months.	154.7	4.13	2.83	2.14	3.03
" one month from solstitial months....	157.7	5.05	2.84	2.25	3.38
" June and December (solstitial).....	167.6	5.16	2.77	2.42	3.45
II.					
" December and January (perihelion)..	150.4	4.56	2.99	1.60	3.05
" November and February.....	138.7	4.04	3.00	1.52	2.90
" October and March.....	146.5	4.20	3.08	1.85	3.04
" September and April.....	153.8	4.55	2.70	2.32	3.19
" August and May.....	180.3	5.14	2.57	3.05	3.58
" July and June (aphelion).....	172.3	5.73	2.48	3.22	3.81
" October to March, inc. (perihelion)...	145.2	4.27	3.02	1.66	2.98
" April to September, inc. (aphelion)...	168.7	5.14	2.58	2.87	3.53
" November to Febr'y, inc. (perihelion)	144.5	4.30	3.00	1.56	2.95
" Sept., Oct., March, April (equinoctial)	150.2	4.38	2.89	2.09	3.12
" May to August, inc. (aphelion).....	176.3	5.44	2.52	3.14	3 70
III.					
" March and April (vernal equinox)....	152.4	3.82	2.33	1.68	2.61
" Jan. to June, inc. "	154.3	4.41	2.50	1.96	2.96
" Sept. and Oct. (autumnal equinox).....	147.9	4.93	3.44	2.49	3.62
" July to Dec. inc. "	159.7	5.00	3.10	2.57	3.56
IV.					
" Spring.....	158.8	4.29	2.35	1.98	2.88
" Summer.....	177.9	5.51	2.57	3.32	3.80
" Autumn.....	148.4	4.86	3.48	2.20	3.51
" Winter.....	142.9	4.17	2.81	1.55	2.84
V.					
" April to August (Full Moon dec. S.) ...	172.4	5.08	2.48	2.84	3.47
" Oct. to Feb. (Full Moon dec. N.).....	144.6	4.33	3.16	1.65	3.04
VI.					
" Warm Semester.....	168.8	5.14	2.58	2.87	3.52
" Cool Semester.....	145.2	4.27	3.02	1.66	2.98

TABLE VII.

Lunar hourly Rainfall at Philadelphia.

☽ hour.	1840–5.	1854–8.	1859–63.	1864–8.	19 7–12 years.
	Inches.	*Inches.*	*Inches.*	*Inches.*	
0	9.45	9.90	8.60	8.85	36.80
1	11.74	8.43	8.94	9.82	38.93
2	9.37	7.97	8.90	9.47	35.71
3	9.79	9.79	9.22	10.41	39.21
4	9.54	9.32	10.43	11.15	40.44
5	9.25	8.70	10.66	10.73	39.34
6	8.51	9.08	10.59	10.49	38.67
7	8.88	8.23	11.12	10.15	38.38
8	11.07	6.95	13.05	9.57	40.64
9	8.25	7.37	12.46	9.87	37.95
10	7.83	7.84	11.13	9.28	36.08
11	8.45	8.00	11.30	9.20	36.95
12	8.71	7.44	10.92	10.05	37.12
13	7.93	7.83	10.68	9.45	35.89
14	11.52	7.71	9.66	9.60	38.49
15	12.30	8.20	10.09	10.14	40.73
16	11.89	8.46	9.53	10.31	40.19
17	11.17	8.16	9.44	10.05	38.82
18	11.19	8.66	9.00	9.81	38.66
19	10.23	9.46	9.54	9.33	38.56
20	9.41	9.53	9.80	9.03	37.77
21	11.34	9.52	10.13	9.55	40.54
22	10.75	9.63	8.96	9.70	39.04
23	11.78	10.17	8.59	8.95	39.49

TABLE VIII.

Solar hourly Rainfall at Philadelphia and Greenwich.

☉ hour.	Philada. 1840–5.	Philada. 1851–68.	Philada. 22 1–12 yrs.	Greenwich 6 years.	Philada. Ratios.	Greenwich Ratios.	Mean Ratios.
	Inches.	*Inches.*	*Inches.*	*Inches.*			
0	9.52	29.27	38.79	2.74	91	77	84
1	9.69	30.31	40.00	3.31	94	93	93
2	10.06	27.41	37.47	3.82	88	107	97
3	10.67	29.44	40.11	4.33	94	121	108
4	9.90	35.70	45.60	4.19	107	117	112
5	10.09	37.93	48.02	4.92	112	138	125
6	9.18	40.27	49.45	3.12	116	87	102
7	10.99	38.14	49.13	2.64	115	74	94
8	12.96	34.24	47.20	3.03	110	85	98
9	14.13	35.13	49.26	2.94	115	82	99
10	10.18	32.40	42.58	3.63	100	102	101
11	10.31	31.44	41.75	3.30	98	93	95
12	9.80	33.60	43.40	3.42	102	96	99
13	9.60	36.88	46.48	3.89	109	109	109
14	8.60	37.68	46.28	3.73	108	105	106
15	8.29	39.43	47.72	3.51	117	99	105
16	8.82	36.12	44.94	4.68	105	131	118
17	9.82	31.52	41.34	4.15	97	116	106
18	9.59	28.95	38.54	4.13	90	116	103
19	9.16	28.07	37.23	3.59	87	101	94
20	9.30	24.96	34.26	3.95	80	111	96
21	9.66	27.84	37.50	3.16	88	89	88
22	9.85	29.75	39.60	3.37	93	95	94
23	10.18	28.82	39.00	2.03	91	57	74

TABLE IX.

Solar hourly Barometric means and Amount of heavy Rains (.25 inch or more per hour) at Philadelphia, 1840–5.

⊙ hour.	Barometer.	Amount of Heavy Rain	⊙ hour.	Barometer.	Amount of Heavy Rain	⊙ hour.	Barometer.	Amount of Heavy Rain
	Inches.	*Inches.*		*Inches.*	*Inches.*		*Inches.*	*Inches.*
0	+.004	.40	8	—.005	.78	16	—.001	2.38
1	—.012	1.30	9	+.002	1.18	17	+.002	2.16
2	—.024	.65	10	+.006	2.02	18	+.012	1.11
3	—.031	.30	11	+.011	.78	19	+.022	3.05
4	—.031	1.04	12	+.002	.51	20	+.028	3.84
5	—.029	1.12	13	+.001	.99	21	+.031	7.70
6	—.023	1.05	14	—.001	1.19	22	+.029	2.18
7	—.014	.96	15	—.003	1.95	23	+.021	2.53

TABLE X.

Monthly Rainfalls.

MO.	PHILADELPHIA AGGREGATES.					ANNUAL AVERAGES.			
	1825 to 1834.	1835 to 1844.	1844 to 1864.	1855 to 1864.	1825 to 1864.	America.	Maritime Eu.	C'nt'l Eu. & Asia.	Mean
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*In.*	*In.*	*In.*	*In.*
Jan.	30.92	36.635	28.067	39.366	143.445	4.51	2.98	1.36	2.95
Feb.	26.06	26.644	34.023	25.015	128.074	3.39	2.45	1.43	2.42
Mch.	31.30	34.142	36.514	33.767	148.048	3.99	2.36	1.71	2.69
Aprl	29.87	40.390	33.830	45.076	156.736	3.66	2.31	1.65	2.54
May	30.20	35.738	41.966	44.332	171.446	5.23	2.39	2.59	3.40
June	36 83	44.223	29.946	48.278	178.012	5.70	2.53	3.00	3.74
July	37.75	49·692	38.220	33.028	166.567	5.77	2.43	3.45	3.88
Aug.	37.28	45.600	42.656	41.883	189.186	5.05	2.75	3.51	3.77
Sept	29.08	33.724	32.099	37.564	150.852	5.45	3.09	3.00	3.85
Oct.	42.25	32.086	28. 12	30.443	145.006	4.42	3.80	1.99	3.40
Nov.	33.66	33.506	36.134	37.417	149.377	4.70	3.55	1.62	3.29
Dec.	29.50	36.171	41.063	38.732	157.271	4.62	3.01	1.85	3-16
Tot'l	394.70	448.551	423.230	454.901	1884.020	56.49	33.65	27.16	39.09

The means (*p.* 528) furnish a basis for interesting comparisons with the similarly deduced magnetic and barometric means (*ante p.* 371). Considered in connection with the Tables (I.—XI.) and the normal curves (Figs. 1—6) they appear to justify the following inferences, most of which, though specially deduced, are presumptively general.

1. The tidal rainfall, like the ocean tides, is affected by "establishments," which depend upon ocean currents, mountain ranges, prevailing winds, and other climatic influences.

2. It is also, like the ocean tides, more marked in low, than in high latitudes.

3. There is a general resemblance between the lunar-daily and the solar-hourly barometric changes. There are, however, only two normal barometric maxima and two minima during the solar day, while there are three of each during the lunar month. The resemblance and the difference seem to be both occasioned by the moon's action upon different portions of the daily barometric ellipsoid. When the moon's upper culmination occurs at night she intensifies, for the whole day, the barometric tendency of the corresponding solar hour; when it occurs by day, this intensification is accompanied and controlled by a marked priming and lagging, which introduce an additional inflection into the lunar curve, — the normal barometric tendencies being accelerated before, and retarded after, new moon.

4. There are some evidences of a similar lunar action upon the monthly barometric means, but a further examination is desirable in order to ascertain the extent and importance of that action.

5. There is a tendency to minima in the frequency and amount of rain near the times of new and full moon, with intermediate maxima. So far as such a tendency is dependent upon the direct action of the sun and moon, positions which favor low ocean tides (quadrature, apogee, south latitude or declination, rising and setting, aphelion, solstice, &c.), favor increased precipitation, and *vice versâ*.

6. But the tidal action is subordinate to thermal influences and changes, which increase either the amount of daily evaporation, the nocturnal condensation of vapor in sea-breezes, or the blending of aerial currents. Such influences affect the "establishment," and in many cases produce opposite results, from similar conditions, in maritime and continental climates.

7. The lunar modification of the barometric ellipsoid, also exerts a much more important influence on the rainfall than the direct and simple tidal agency of the moon. The greatest rains therefore have an octantal rather than a quadrature tendency.

8. The lunar-hourly and the lunar-daily rains, both ordinary and extraordinary, like the lunar-monthly barometric fluctuations, have three maxima and three minima, nearly correspondent in period and opposed in direction to those of the barometer, and attributable to the same lunar priming, lagging and intensification.

9. The solar-hourly ordinary and heavy rains have also an inclination to maxima and minima, which appear to be mainly dependent upon the thermal currents.

10. The principal anomalies in the lunar-daily rainfall at Philadelphia occur near the quadratures, and are attributable to occasional heavy storms. For instance, the abnormal flexures in the curve for 1825–44 (fig. 2), were produced by ten storms, of more than 2.5 inches each, on the 9th–14th and 17th–20th days of the lunar month. It is well to notice that these flexures are added to the curve, without obliterating the traces of barometric mediation.

11. The middle day of the most rainy week in each of the ten years' groupings at Philadelphia occurred after full moon, or during that portion of the lunar month when the moon's action is intensified by a falling barometer and increasing condensation of atmospheric vapor. Schiaparelli likewise found a rainy maximum in Northern Italy, about the time of the last lunar quarter, and Mr. Dines observed that the rain which fell on the 22nd day of the moon's age, in Surrey, "is in all cases above the average, when a period of five years is taken," but I am not aware that any one has hitherto attempted to show the dependence of such a maximum upon any obvious law.

12. A careful examination of the local aerial currents resulting from the moon's barometric and tidal actions, may perhaps help

TABLE XI.—

Age of Moon	0	1	2	3	4	5	6	7	8	9	10	11
Surrey, 1825-64	100	98	97	100	102	102	100	101	105	107	104	101
Philadelphia, 1825-64	93	93	96	100	101	99	97	97	97	98	98	97
" 1825-44	93	88	89	95	96	94	93	96	99	103	105	106
" 1845-64	93	97	102	105	107	105	101	97	95	93	92	88
" 1825-68	93	94	97	102	103	100	97	96	96	96	95	94
" 1 inch or more	78	76	87	101	106	100	94	94	93	87	81	78
" 1.5 inch or more	80	71	76	95	109	108	101	99	99	92	81	72
" 2 inches or more	73	57	56	72	86	85	78	78	79	77	74	72
" 2.5 inch or more	69	68	65	70	77	70	61	65	84	97	92	81
" > .25 inch per hour.	82	61	49	44	44	50	56	58	59	60	62	69
" 2 inches or less	96	100	105	108	106	102	101	100	100	100	99	98
" No. > .25 inch	96	99	104	105	103	102	101	102	100	100	100	99
" Average fall	93	95	97	101	102	99	97	97	97	97	96	97
" ☽ hourly	99	98	98	99	101	102	102	102	101	102	101	100
" ☉ hourly	91	91	92	94	99	105	110	111	114	113	112	109
Greenwich, ☉ hourly	81	90	100	109	115	118	113	104	94	86	84	87
Mean ☉ hourly	86	90	96	101	107	111	112	108	104	100	98	98
Hours of the day	0	.8	1.6	2.4	3.2	4	4.8	5.6	6.4	7.2	8	8.8

to reconcile the discrepant results obtained by different observers of the lunar-daily variations in temperature.

13. These considerations, with the supplementary aid of sufficient local observations to adjust the hourly, daily and monthly "establishments," may furnish data for valuable predictions of normal meteorological conditions.

14. After the direction, magnitude and frequency of the normal changes in the atmospheric pressure and currents have been satisfactorily determined, it seems reasonable to hope that an improved system of "forecasts" may be established which will be very advantageous to agriculture and commerce.

15. The principal terms for meteorological predictions may be thus arranged, in the order of their apparent relative importance at Philadelphia:

Daily range of temperature and consequent aerial currents;
Lunar disturbance of daily barometric pressure;
Distance of the sun;
Solar declination;
Lunar disturbance of monthly barometric pressure;
Lunar hour angle and daily tide;
Lunar declination;
Phase of the moon;
Moon's distance;
Solar tide;
Moon's latitude.

Normal Ratios of Rainfall.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
98	97	98	98	97	96	97	99	103	104	101	98	99	101	100	99	100	101
95	92	89	91	99	109	116	117	112	107	105	105	102	98	100	103	100	95
105	101	94	91	95	102	108	109	108	110	115	116	108	96	91	95	100	98
85	84	85	91	103	116	124	123	115	103	95	93	95	101	108	109	101	94
94	94	96	100	106	113	115	113	108	104	102	102	99	96	98	101	99	95
78	82	86	99	111	124	128	122	116	115	116	114	107	103	108	114	107	91
69	70	79	94	113	131	136	129	121	119	116	106	96	97	110	119	112	96
73	81	95	107	113	128	145	149	144	142	139	128	113	110	120	122	110	92
78	94	120	133	130	136	153	158	143	127	126	126	120	116	113	93	68	64
72	68	64	54	59	72	89	106	116	118	128	153	192	239	251	225	177	124
98	97	96	99	105	110	109	106	101	96	95	97	96	93	94	97	97	95
98	97	97	100	106	110	110	106	101	97	96	98	96	93	94	97	97	95
98	100	101	102	103	106	107	105	103	103	103	103	99	98	101	105	102	97
97	96	96	96	96	98	101	103	103	102	101	100	100	101	102	102	101	100
106	103	102	103	106	108	109	108	104	99	94	90	86	85	86	89	91	91
91	94	97	100	102	105	108	112	115	116	114	111	107	102	96	89	83	79
98	99	99	101	104	107	109	110	109	108	104	100	96	93	91	89	87	85
9.6	10.4	11.2	12	12.8	13.6	14.4	15.2	16	16.8	17.6	18.4	19.2	20	20.8	21.6	22.4	23.2

EXPLANATION OF FIGURES.

The notched horizontal line, in each figure, represents the mean daily or hourly value; each vertical space represents a deviation of .03 of the mean value, in the rain curves, or of .003 of an inch in the barometric curves; each horizontal space represents a day in the abscissas of the monthly curves, or forty-eight minutes in the abscissas of the daily curves.

Fig. 1. Total lunar-daily rainfall.

Philadelphia, 1825–44; _____ continuous line.
Surrey, 1825–44; ..... dotted line.

Fig. 2. Total lunar-daily rainfall at Philadelphia.

1825–44; ..... dotted line.
1845—64; - - - - - - broken line.
1825–68; _____ continuous line.

Fig. 3. Lunar-daily rains at Philadelphia.

No. of storms exceeding .25 in.; ..... dotted line.
Average fall; - - - - - - - - - - - - broken line.
Amount of rain in moderate storms; _____ continuous line.

Fig. 4. Total hourly rainfall.

Greenwich, solar hourly; ..... dotted line.
Philadelphia; " " _____ continuous line.
" lunar hourly; - - - - - - broken line.

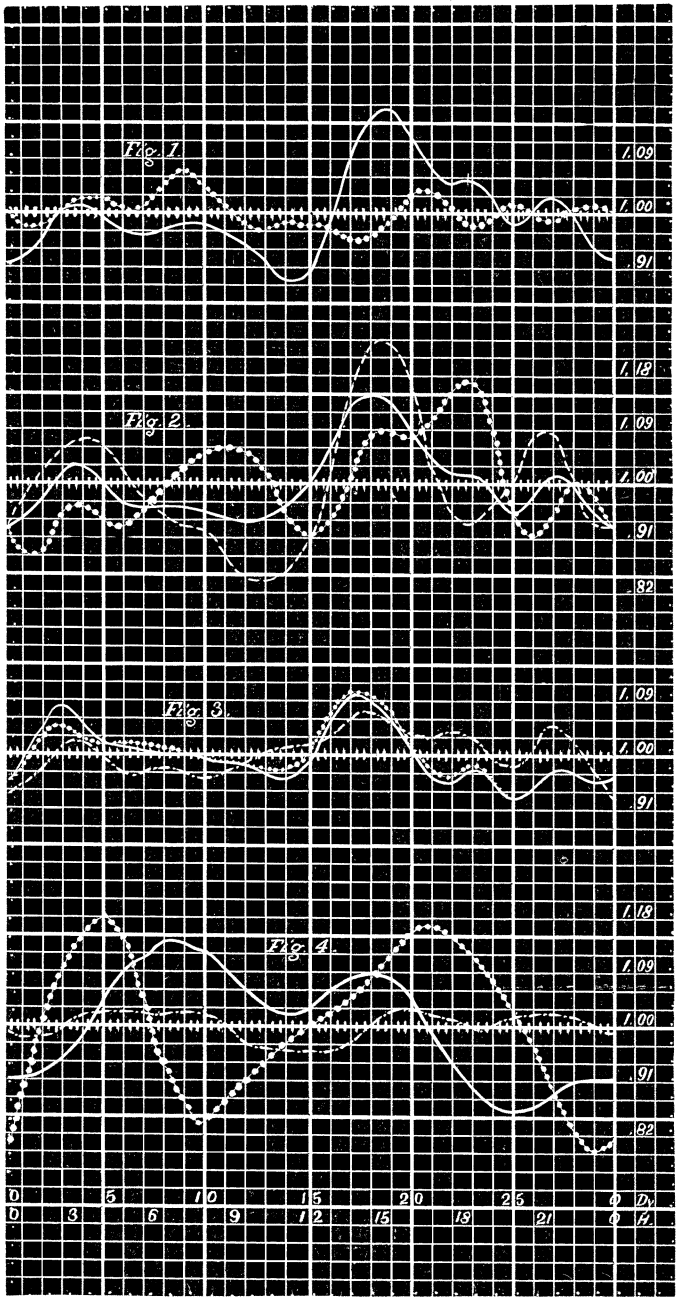
Fig. 5. Barometric fluctuations at Philadelphia.

Solar-hourly; _____ continuous line.
Lunar-daily; - - - - - - - broken line.

Fig. 6. Heavy rains at Philadelphia.

Lunar-daily amounts, in storms of 1 inch or more; dotted line.
Do. do. do. 1.5 in. or more; broken line.
Do. do. do. 2 in. or more; light line.
Do. do. do. 2.5 in. or more; heavy line.
Solar-hourly, exceeding .25 in. per hour; dotted broken line.

CURVES OF RAINFALL.



CURVES OF PRESSURE, AND OF HEAVY RAINS.